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National Aeronautics and Space Administration

Domestic and International Advances in Numerical Air Quality Prediction at Baron Advanced Meteorological Systems

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Baron Advanced Meteorological Systems, LLC

and

C. Coats, J. Vukovich, D. Olerud, T. Smith, R. Husar, C. Hsu, M. J. Jeong, J. Warner, C. Salustro, B. Do, and D. Roy

2010 National Air Quality Conference: Air Quality Forecast Modeling, Wednesday, March 17, 2010; Raleigh, NC

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Talk Outline

- Introduction to NAQP at BAMS
- International Deployment of Operational NAQP DSS: Meso-America (CATHALAC)
- Domestic System Improvements, Evaluation and Status
- Summary

Introduction:
Baron Adv. Met Systems: 12th year in Operational Numerical Air Quality Systems

- MAQSIP-RT
  - Began in 1998
  - Participated in all major field programs since 2000
    - TXAQS-2000, NEAQS-2001, 2002, 2004 (McHenry, et al., 2004, Bull. Amer. Meteorological Society), TEXAQS-06
    - Performance Statistics leader among all models forecasting ozone throughout all of these field programs
    - Upcoming: CALNEX (May/June 2010)

- CMAQ-DA (improved SOA)
  - NASA grant/cooperative agreement – AOD Data-Assimilating Version
    - Operational Capability – about 6 months out for DA version
    - Near-term emissions improvements (soon)

- Both MAQSIP-RT and CMAQ-DA
  - Coupling to NASA Land-Information System: Improved Emissions

- MATC–H (under development)
  - Multi-scale Atmospheric Transport and Chemistry – Hybrid Parallel

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Introduction:
Baron Adv. Met Systems 12th year in Operational Numerical Air Quality Systems

- **Goal: To continually improve operational decision support for issuance of air quality forecasts by numerous clients**
  - **TOOLS *DIFFER* FROM NATIONAL EPA/NCEP CMAQ model in all cases – thus they all add value:**
    - **almost all meteorological forecasts are based on more than one model—**
    - **WHY NOT AIR QUALITY?? BAMS provides the additional hi-value modeling systems that allow AQ forecasters to make forecasts with increased confidence and certainty**

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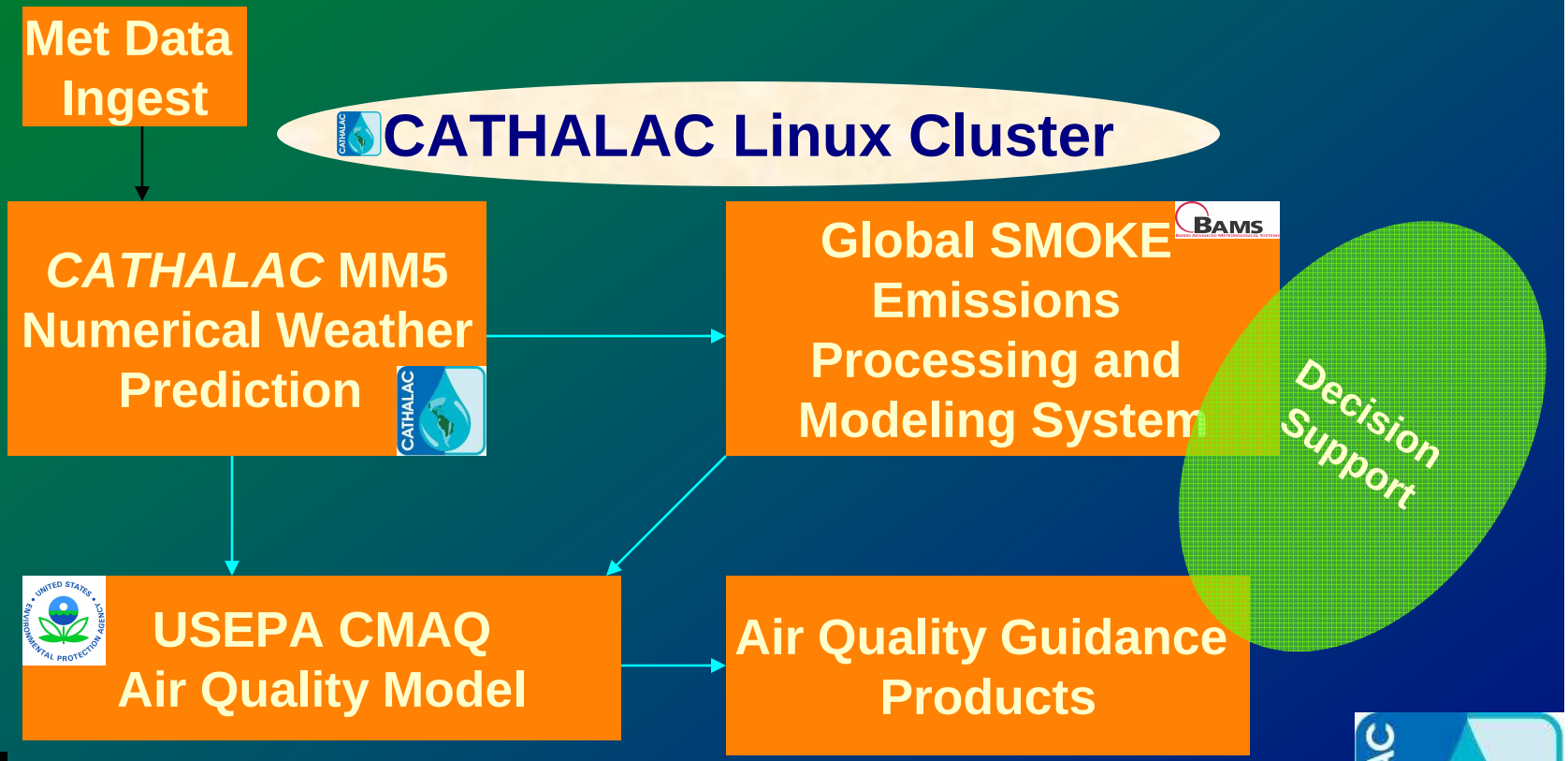
SERVIR Application: Operational NAQP System at SERVIR-CATHALAC

Component Models and DataFlows



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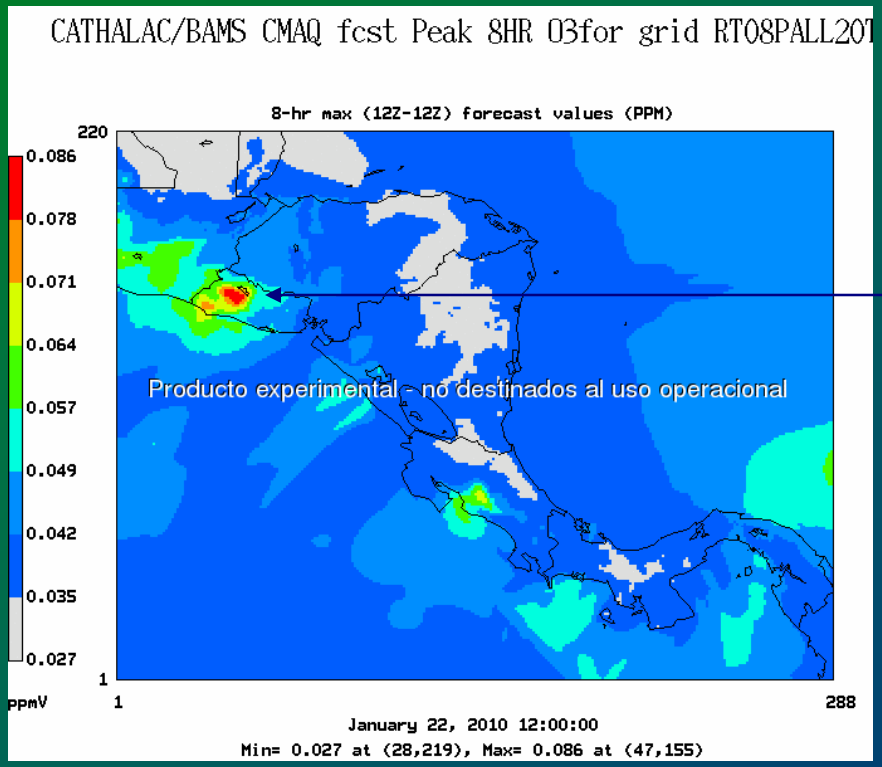
SERVIR Application: Operational NAQP System at SERVIR-CATHALAC



- Next day model forecast for San Salvador, El Salvador, CA
- peak 8-hour ozone > 85PPB
- Would violate the older US ozone standard if it occurs
- Forecaster could use this guidance to issue a public alert or recommend preventative action

SERVIR Model Ozone Forecast

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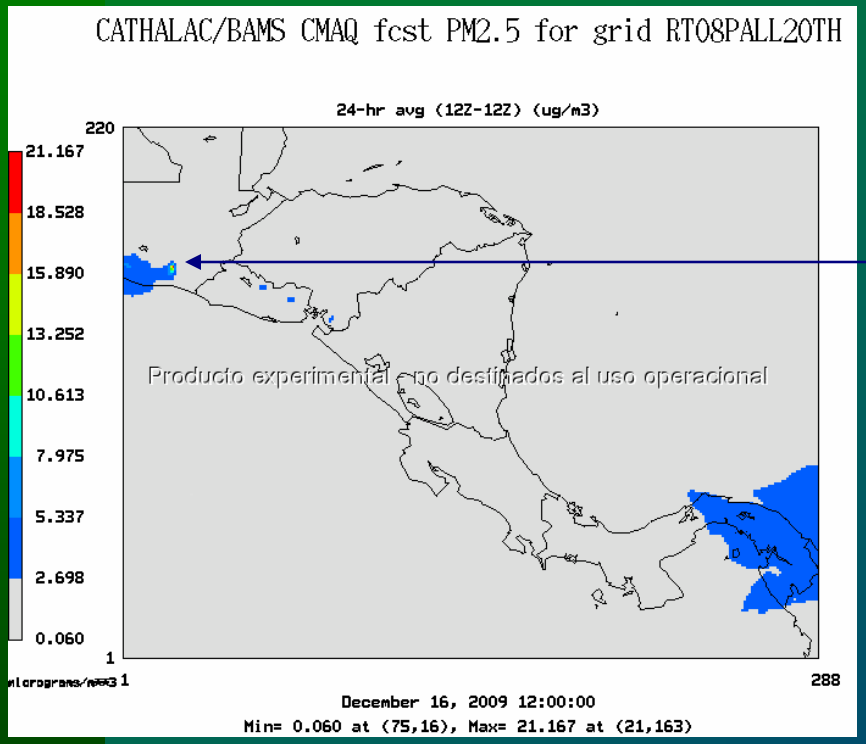

- **Next day model forecast for Guatemala City, Guatemala**
- **24-hour average PM2.5 > 21 ug/m3**
- **Would indicate moderate PM2.5 pollution in the US**
- **Forecaster could use this guidance to issue a public forecast for moderate air quality**

C_{low}	C_{high}	I_{low}	I_{high}	Category
0	15.4	0	50	Good
15.5	40.4	51	100	Moderate
40.5	65.4	101	150	Unhealthy for Sensitive Groups
65.5	150.4	151	200	Unhealthy
150.5	250.4	201	300	Very Unhealthy

SERVIR Model PM2.5 Forecast

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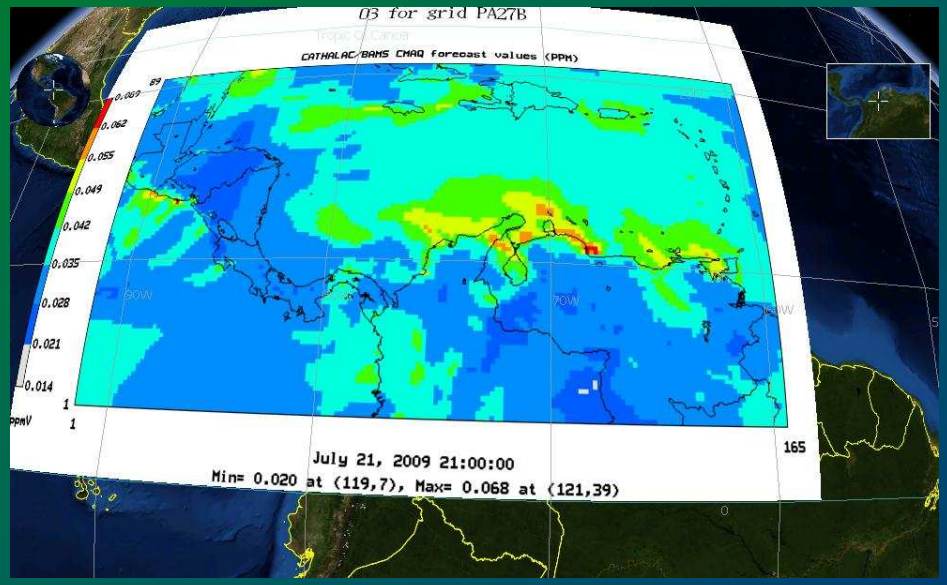
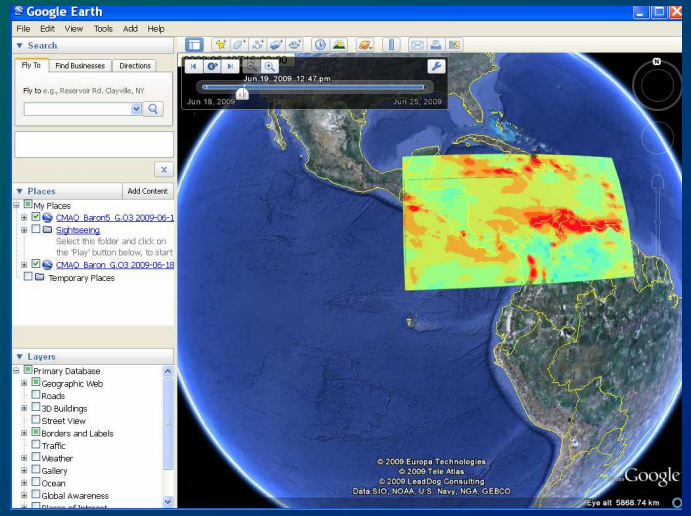
SERVIR Model Can Be Visualized in a Number of Ways



NASA SERVIR-VIZ application



Google Earth

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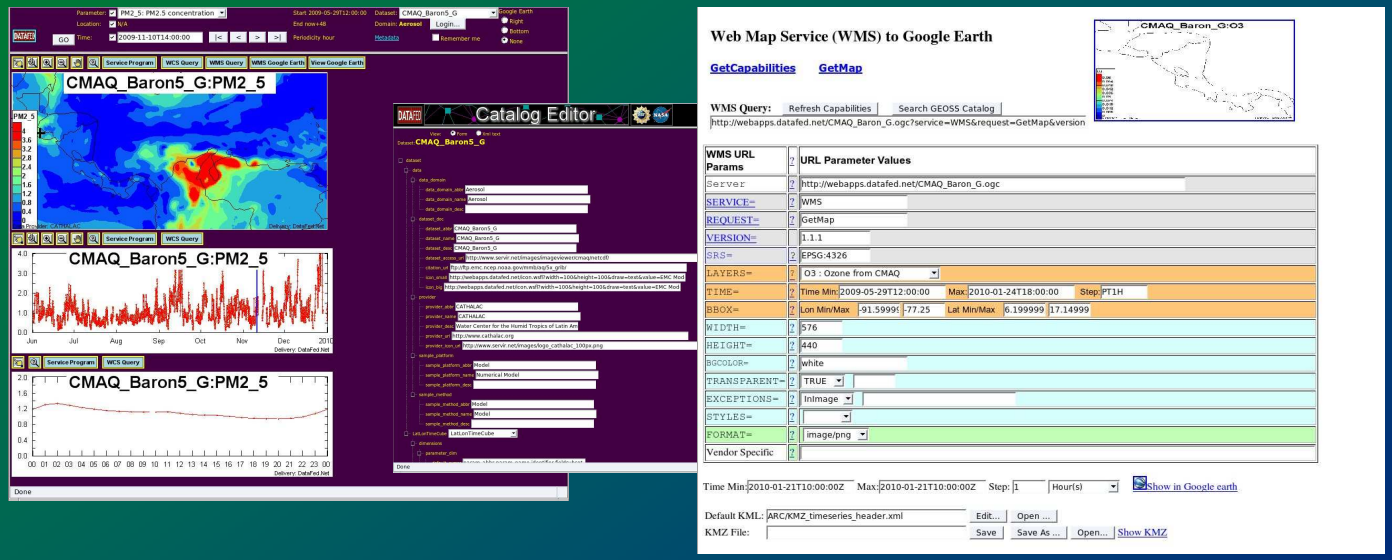

Examples: GEOSS compatibility

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International Deployment: CATHALAC

Next Steps at CATHALAC

- Improve SMOKE emissions to include primary PM2.5 estimate
- Augment CMAQ output to include additional specialized outputs
- Implement forecast model analysis at monitor (real-time)
- Conduct additional CMAQ-based SMOG BLOG training
- Assist CATHALAC in improving meteorological inputs

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Model DataFlows

Met Data Ingest

MESOCALE MODEL (MM5 or WRF)

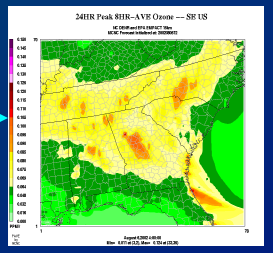
SMOKE-RT Emissions Processing and Modeling System

Photochemical Model (MAQSIP-RT)

NASA LIS
(Land Information System)

Chemical Data Ingest and Assimilation: Deep Blue; PM Surface

Photochemical Model (CMAQ w/ improvements)



Guidance Products

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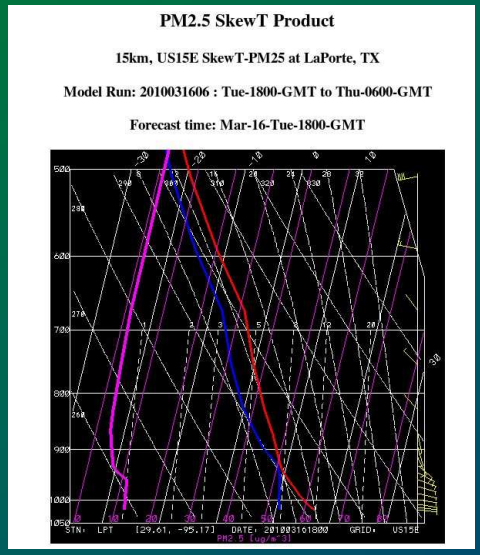
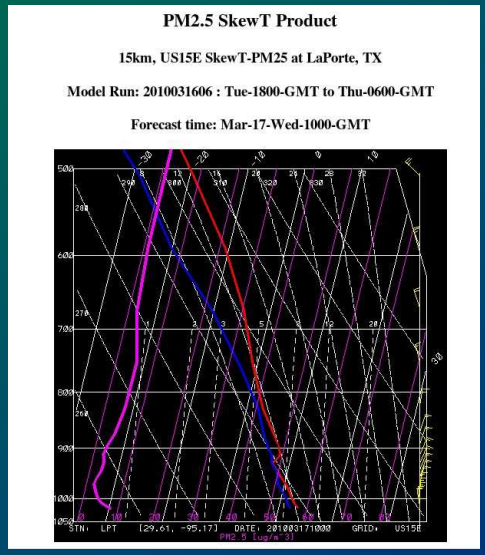
Products and Services Improvements

La Porte (Houston):

Forecast PM2.5: @ 18Z well-mixed PBL





Followed by Forecast PM2.5: @ 10Z Nocturnal Inversion

BAMS has introduced forecast PM2.5 Skew-T diagrams and animations which have been well-received by forecasters

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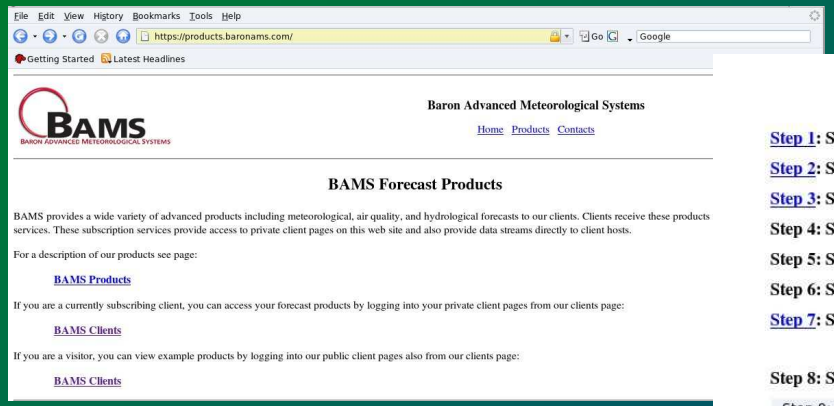
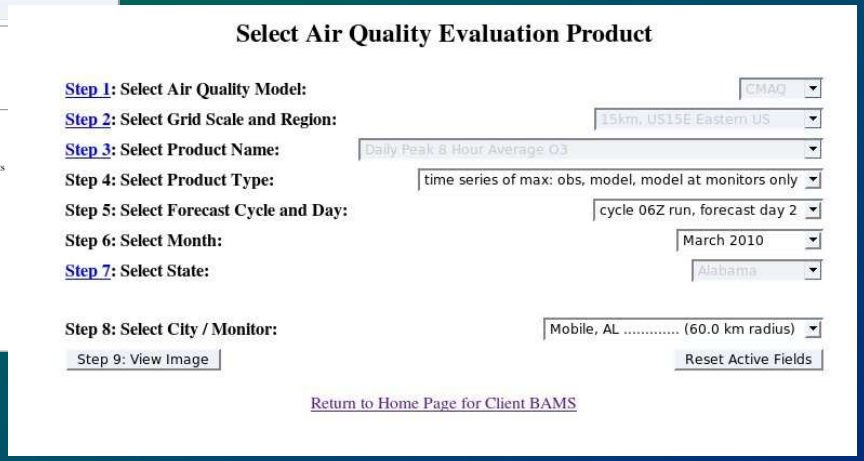
Products and Services Improvements





All clients will now have online real-time access to model evaluation data for their regions of interest in a wide variety of formats for both PM2.5 and ozone (for both forecast modeling systems)

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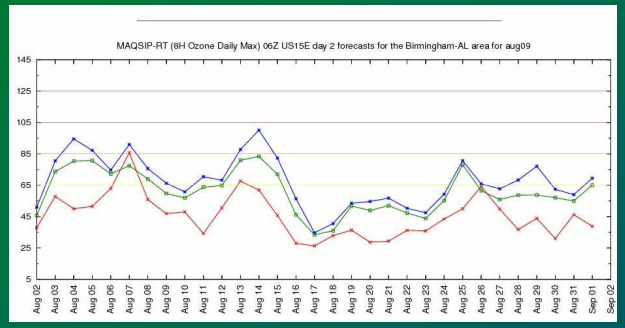
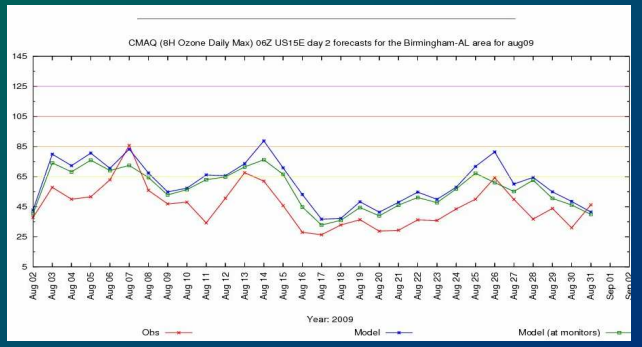
Recap of 2009-10 Performance: SE US (Birmingham, AL)

O3: MAQSIP-RT

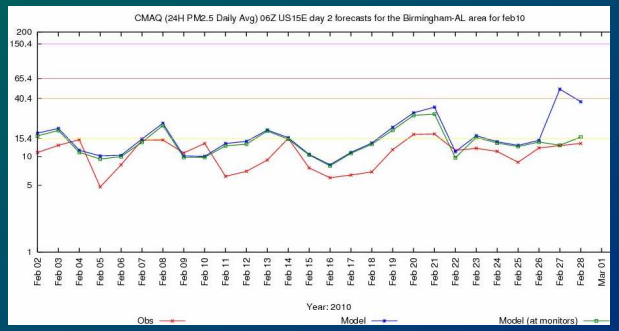


Aug 2009

O3: CMAQ



Note
Over-prediction (both models, both pollutants)



Feb 2010

PM25: CMAQ

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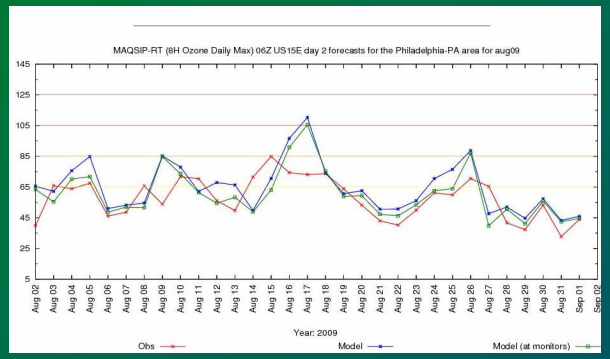
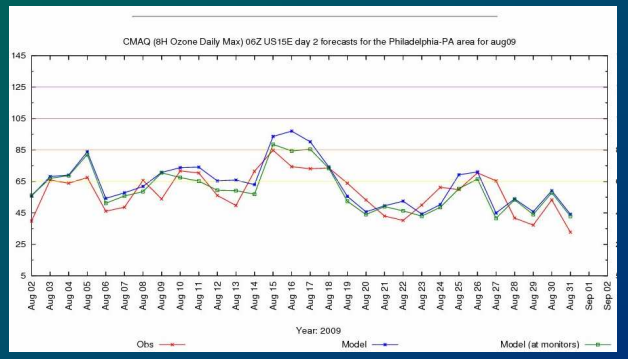
Recap of 2009-10 Performance: NE_Cor (Phila)

O3: MAQSIP-RT

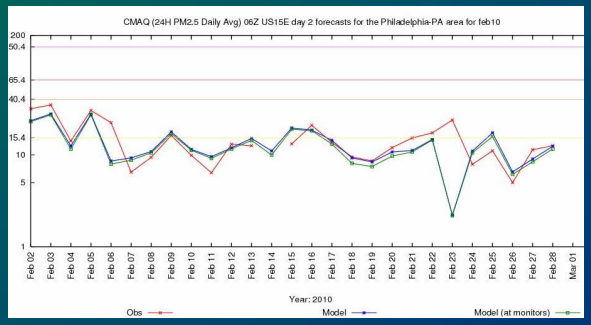


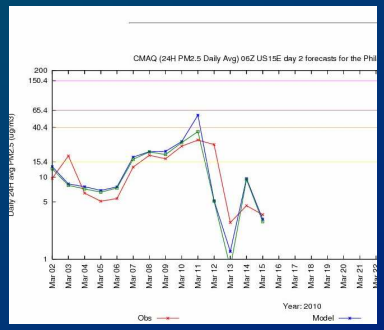
Aug 2009

O3: CMAQ



Both models tracking reasonably wel (both pollutants)





PM25: CMAQ

Feb/Mar 2010

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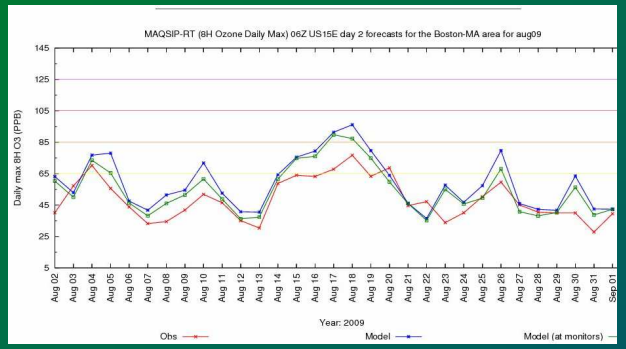
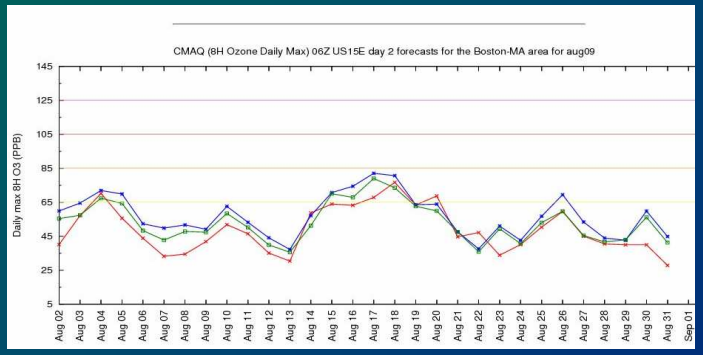
Recap of 2009-10 Performance: New Englang (Boston)

O3: MAQSIP-RT

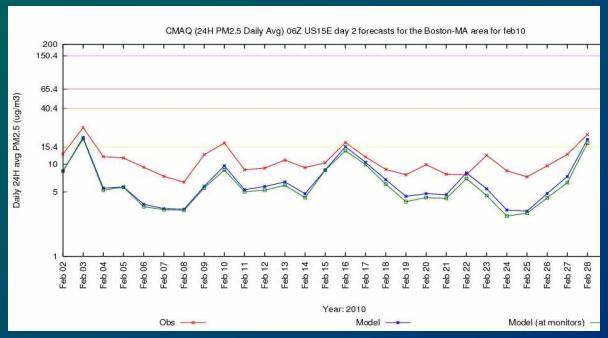


Aug 2009

O3: CMAQ



Note: O3 Over-prediction (both models); PM2.5 Underprediction (CMAQ)



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PM25: CMAQ

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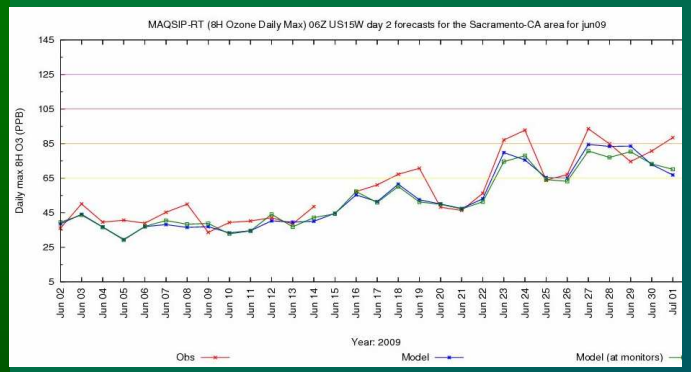
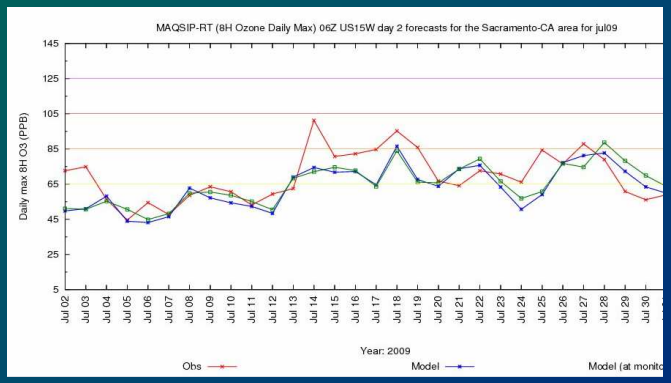
Recap of 2009-10 Performance: Sacramento

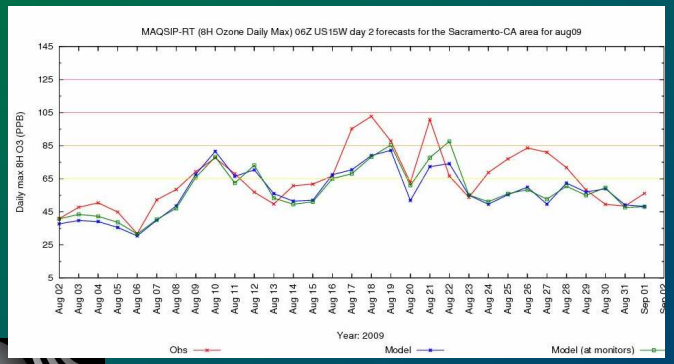
Note: MAQSIP-RT tracking reasonably well but under-forecasting some peaks

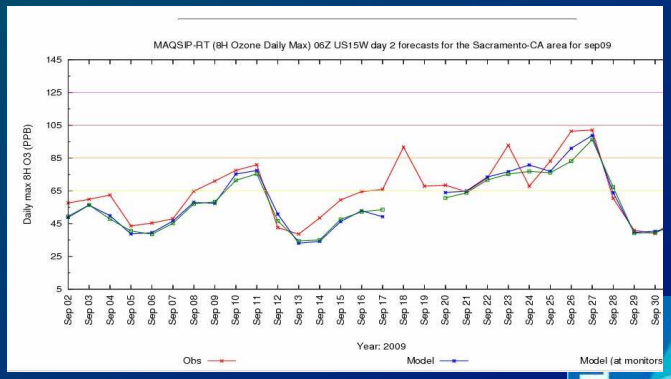
O3: MAQSIP-RT





Jun/Jul 2009





Aug/Sep 2009

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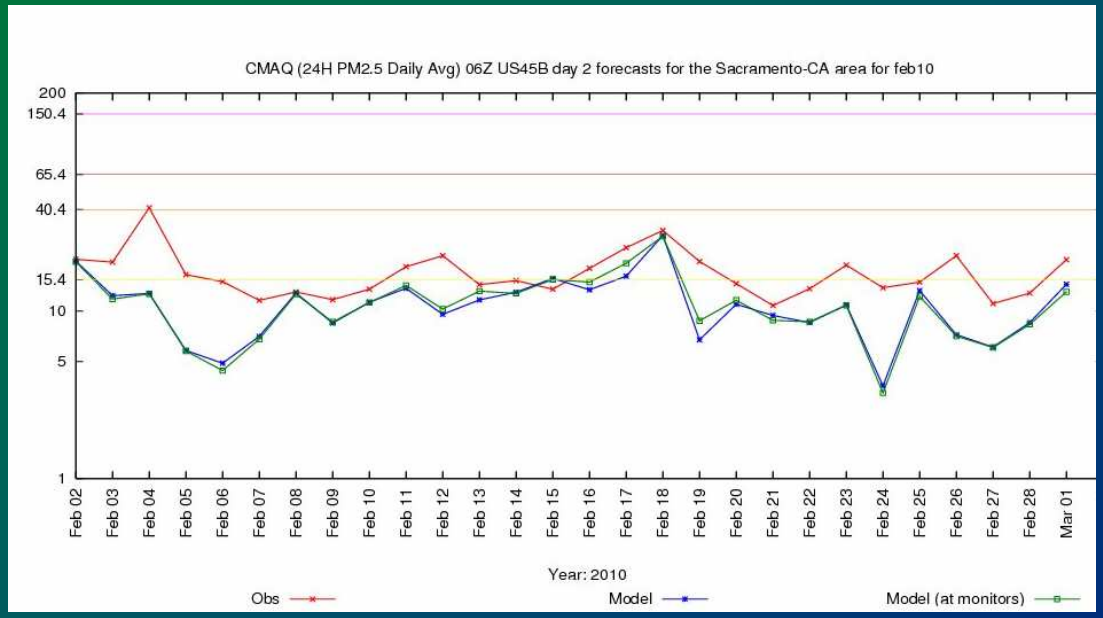
Recap of 2009-10 Performance: Sacramento

Note: CMAQ Under-Forecast PM2.5

PM25: CMAQ (45KM)



Feb 2010

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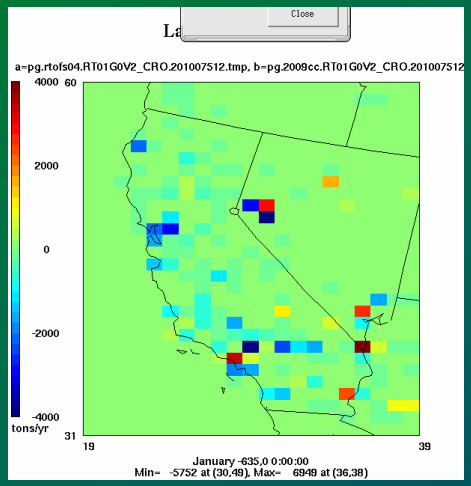
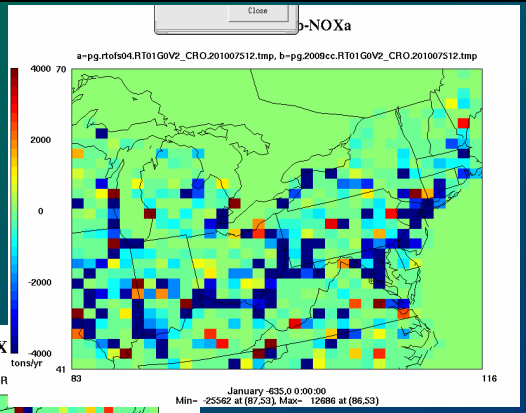
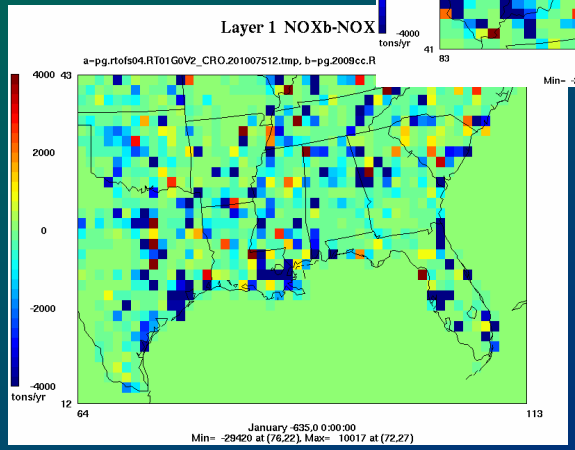
Domestic System

Point Source NOx by Region

Near Term Emissions Improvements







Differences: Annual ave (tons/year) 2009 minus 2002

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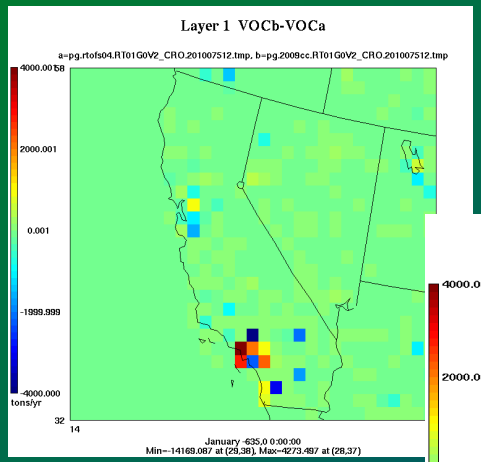
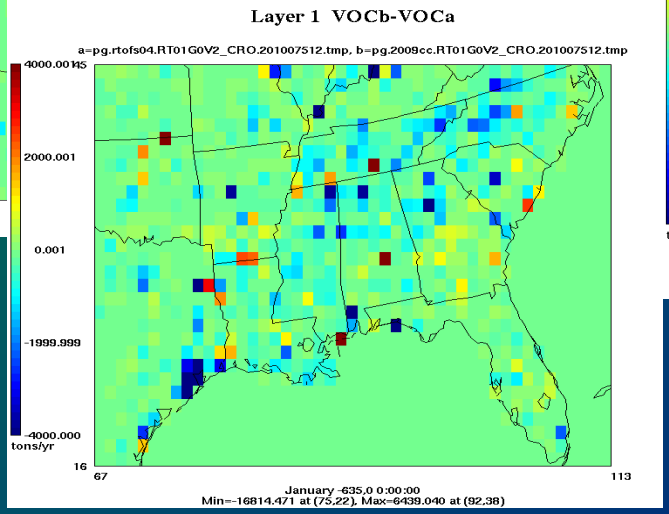
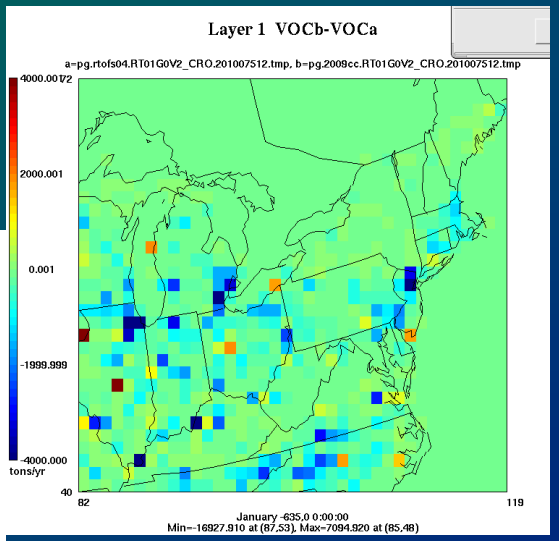
Near Term Emissions Improvements

Point Source VOC by Region







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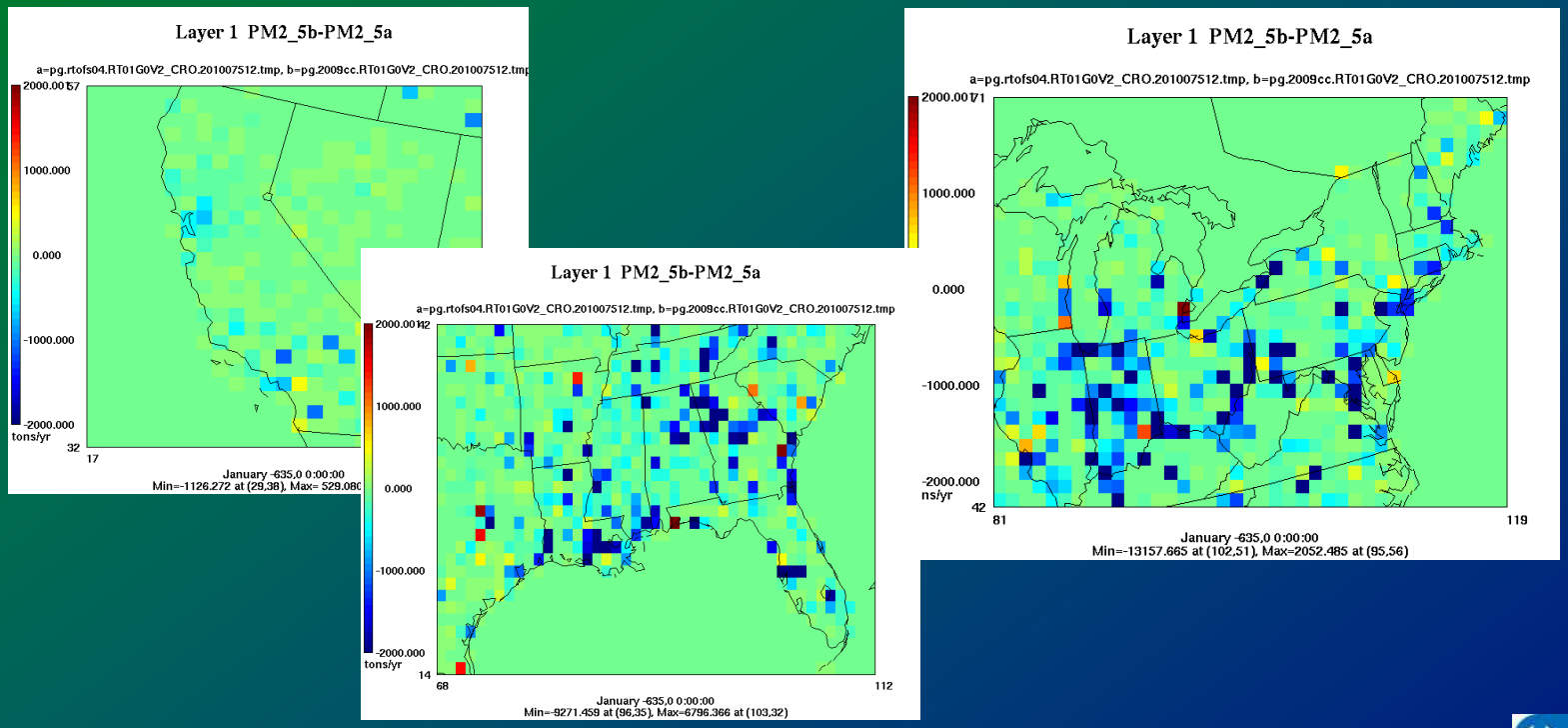
Point Source PM25 by Region

Near Term Emissions Improvements



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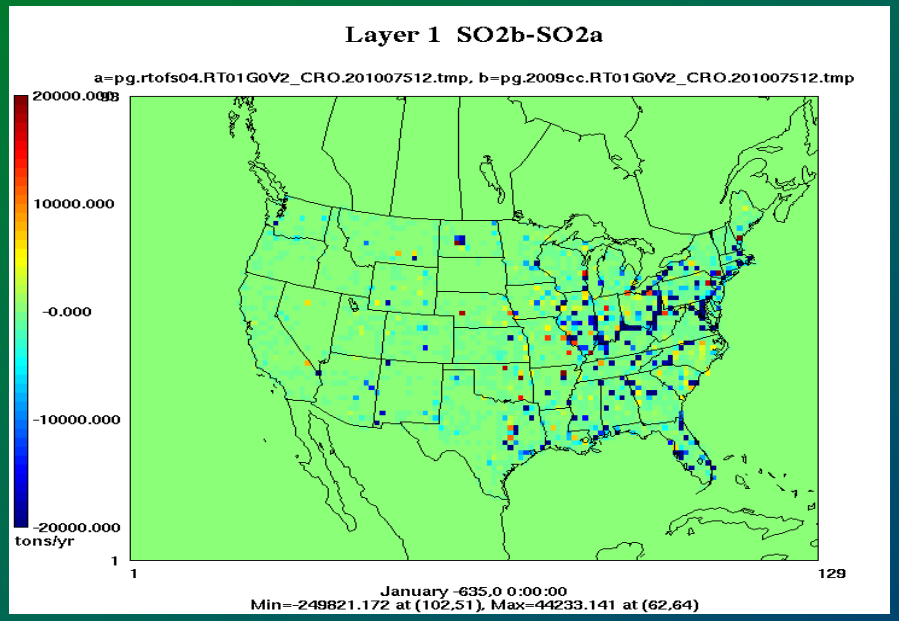
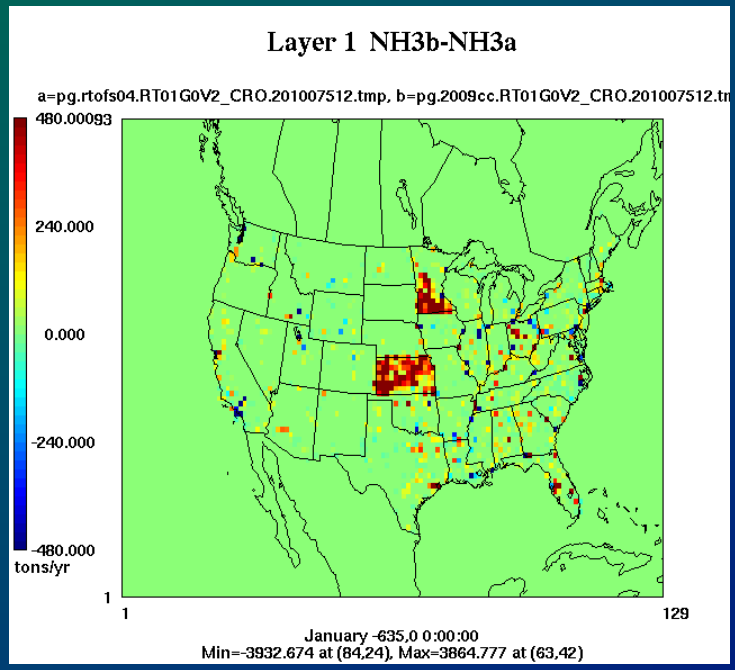
Point Source SO2 and NH3

Near Term Emissions Improvements





Differences: Annual ave (tons/year) 2009 minus 2002

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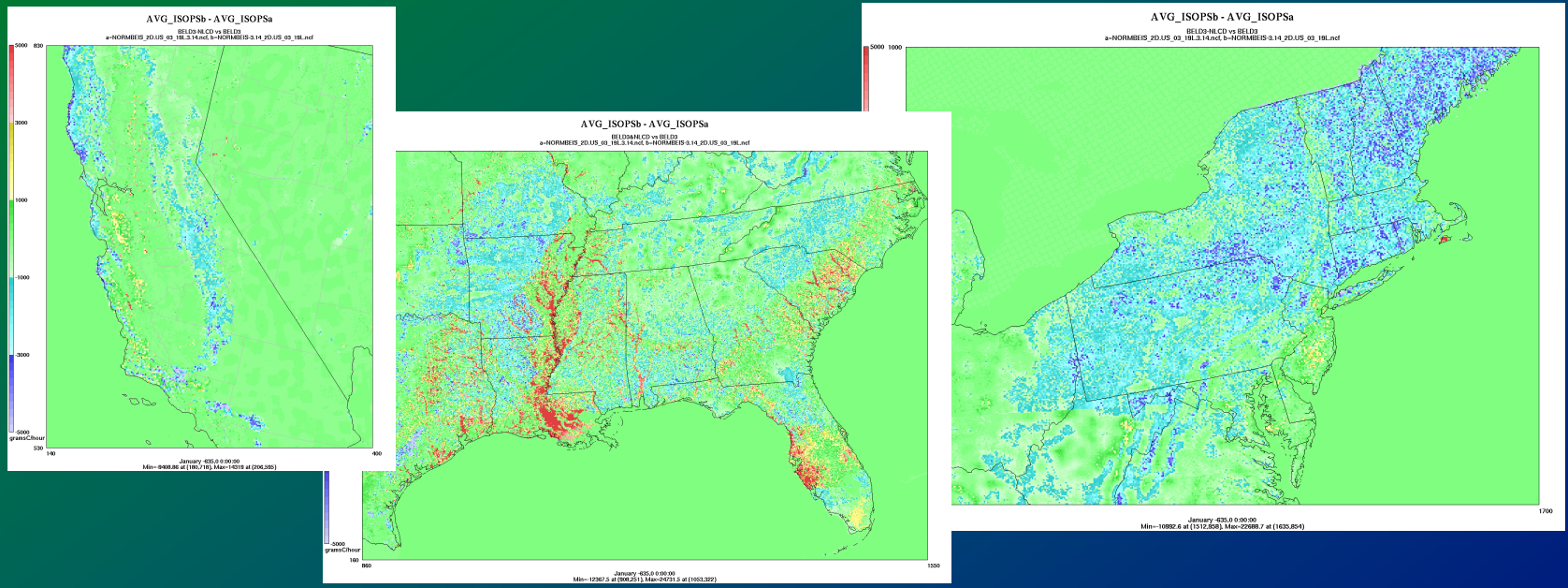
Biogenics: Coupled to 3KM operational LSM updated w/ NLCD and terrain-downscaled meteorology

Near Term Emissions Improvements



1km-scale DIFFERENCES in annual average ISOPRENE emissions with NLCD-BELD

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Domestic System

Data Assimilation Status

- Background and Observational EC matrices under development (using AERONET as reference)
- CMAQ benchmark against DENR complete
- CMAQ code enhancements ongoing

$$T_{b\lambda} = H_{mt}(C_m) + \varepsilon_{b\lambda} \quad (1)$$ Model Mass Concentration to AOD

$$T_{a\lambda} = T_{b\lambda} + P_b H^T [H P_b H^T + R_o]^{-1} [T_{o\lambda} - H(T_{b\lambda})] \quad (2)$$ Data Assimilation Step

$$C_m = H_{tm}(T_{a\lambda}) + \varepsilon_m \quad (3)$$ Analyzed AOD to Model Mass Concentration

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Summary

BAMS Continues to be the leading provider of air quality forecast decision support:

- Models
  - MAQSIP-RT
  - CMAQ-DA w/ improved SOA
  - Emissions Modeling
  - MATC-H
- International
  - SERVIR-based implementation of CMAQ at CATHALAC
  - Potential for additional international applications
- Domestic System
  - New products/services: PM25 SkewT's; Full evaluation suite
  - 2009 Performance Analysis Results
    - O3 (generally hi-bias in the east—both models)
    - PM25 (generally hi-bias in SE)
    - West: both models slight under-prediction
  - Near term improvements
    - Adoption of 2009 point source inventory
    - Implementation of updated LSM-coupled biogenics
    - Implementation of variational data-assimilation for AOD

BAMS AQ Forecast Systems:

The Leader in Advanced Air Quality Forecast Modeling for Decision Support

Please stop by our booth in the Exhibit Hall to learn more

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Acknowledgements

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